THE LOWER PALAEOZOIC STRATIGRAPHY AND FAUNAS OF THE TAURUS MOUNTAINS NEAR BEYŞEHİR, TURKEY. II. THE TRILOBITES OF THE SEYDİŞEHİR FORMATION (ORDOVICIAN)

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CONTENTS

SYNOPSIS

Trilobites from the upper half of the Seydişehir Formation near Beyşehir are described. Almost all are represented only by disarticulated fragments but the following genera are identified : *Geragnostus, Ampyx* ?, *Colpocoryphe, Neseuretus, Symphysurus, Paramegalaspis, Megistaspis, Ptychopyge* and *Taihungshania.* Three new species are described : *Geragnostus lycaonicus, Neseuretus sexangulus* and *Symphysurus blumenthali.* The assemblage is of Lower Arenig age and mostly of Tethyan type, but some genera from the highest strata exhibit Balto-Scandinavian affinities.

I. INTRODUCTION & ACKNOWLEDGMENTS

THE present paper is the first of a series describing the Lower Palaeozoic trilobites of that area of Turkey which lies between Beyşehir and Seydişehir (see Fig. 1), some 100 kilometres south-west of Konya. An earlier paper (Dean & Monod, 1970) introduced the reader to the succession of Cambrian and Ordovician strata there and gave a series of sketch-maps showing the position of fossil localities and their stratigraphical position, if known.

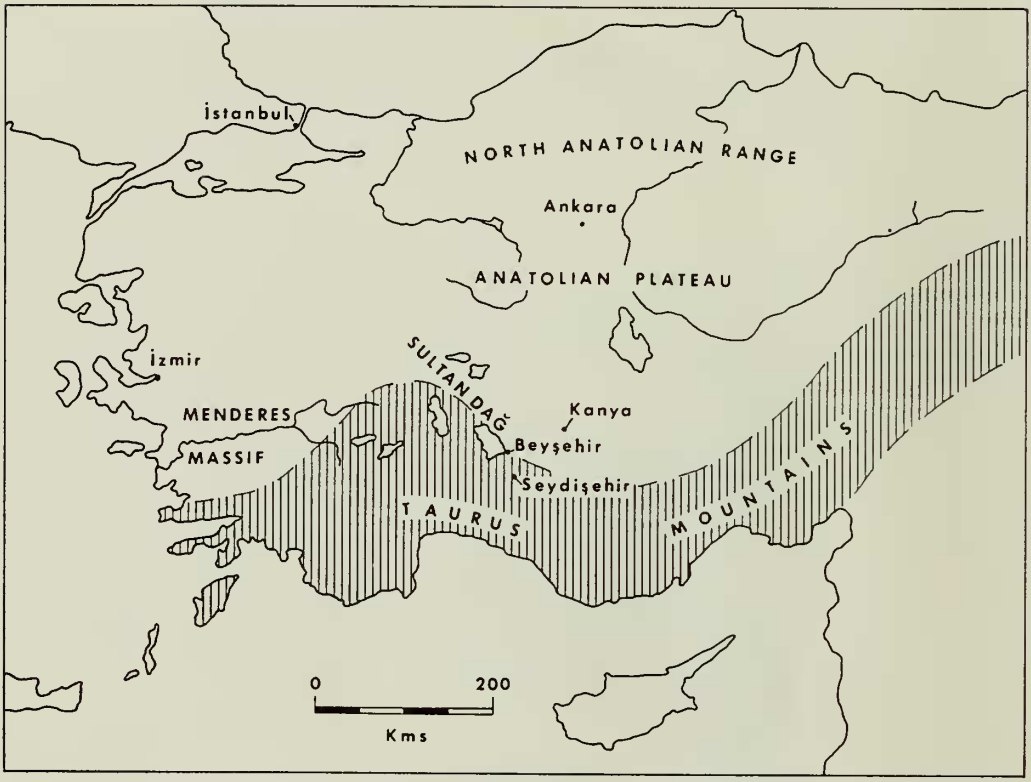

FIG. 1. Outline map of Turkey showing the location of the Beyşehir-Seydişehir district in relation to the Taurus Mountains (vertical shading) and other major structural units.

The Seydişehir Formation, at least part of which is Lower Ordovician in age, forms by far the largest Lower Palaeozoic outcrops of the region (see Fig. 2), and comprises the Seydişehir Shales, silty shales more than 1000 metres thick with occasional resistant bands of brown-weathering, sandy limestone, followed by 20 metres of coarser beds, the Upper Greywackes. The rocks, often tectonically deformed, are largely barren, but at some localities, all of which represent levels in the upper half of the Seydişehir Formation, the harder bands have yielded fossils. The latter include graptolites which indicate an Arenig age, possibly both the Extensus and Hirundo

Zones of that series, together with a few brachiopods and molluscs, and the trilobites described in the following pages. The trilobite remains are almost always broken and comprise about fifty fragments, mostly pygidia and librigenae, in addition to the specimens now described ; they are difficult to determine specifically, but at least

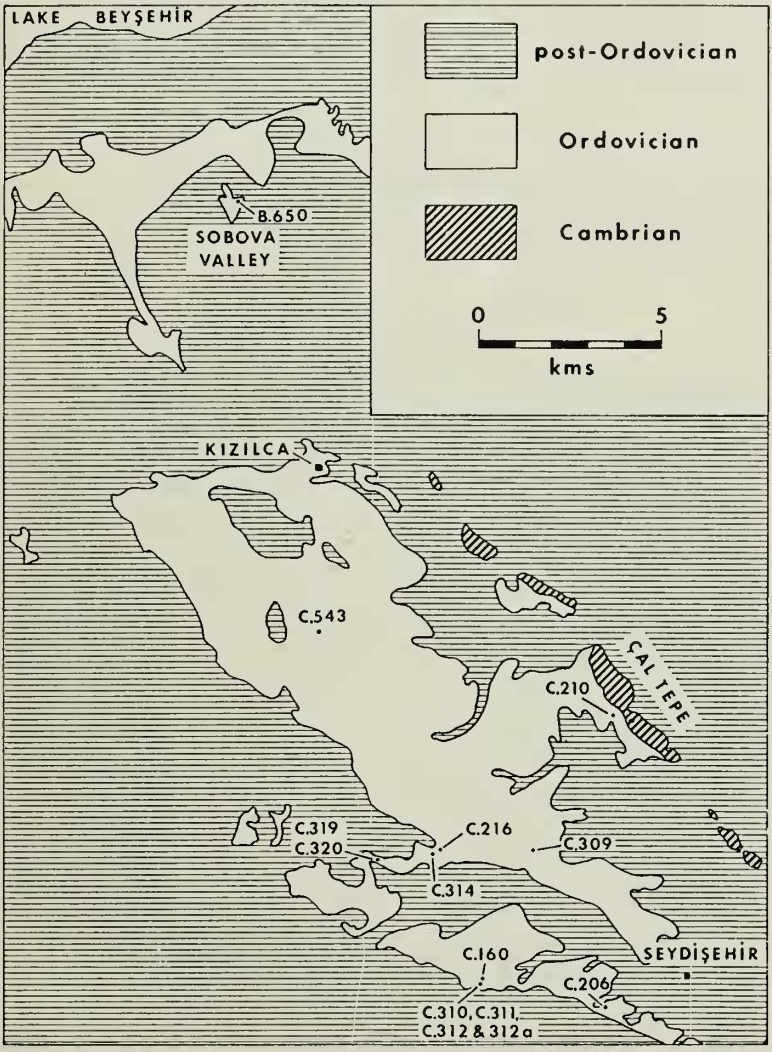

Fig. 2. Sketch-map showing the situation of fossil localities in the Seydişehir Formation of the district between Beyşehir and Seydişehir.

eleven genera have been collected. Fossils were found for the first time in the Seydişehir Shales by M. Olivier Monod, who not only placed his material at my disposal but also introduced me to the geology of the Beyşehir region during a visit in the

summer of 1968. I am much indebted to him for his co-operation and to Prof. H. B. Whittington who has kindly read and criticized the manuscript.

II. SYSTEMATIC DESCRIPTIONS

The terminology employed here is essentially that proposed by Harrington, Moore & Stubblefield in the Treatise on Invertebrate Paleontology (*in* Moore 1959 : O 117–O 126), though that describing *Geragnostus* follows Whittington (1963 : 28).

Family **AGNOSTIDAE** M'Coy 1849

Genus ***GERAGNOSTUS*** Howell, 1935

TYPE SPECIES. *Agnostus sidenbladhi* Linnarsson, 1869.

Geragnostus lycaonicus sp. nov.

Pl. 1, figs. 1, 3, 4, 7, 8

DIAGNOSIS. Species of *Geragnostus* distinguished particularly by strongly convex pygidium with axis about five-sixths of total length. Anterior part of axis formed by two well-defined axial rings with median lobes joined to form a longitudinal lobe; remainder of axis scarcely defined, but with median tubercle near elliptical tip.

HOLOTYPE. BM. It.7992 (Pl. 1, figs. 3, 4, 8).

PARATYPES. BM. It.7991 (Pl. 1, fig. 1) ; It.7993 (Pl. 1, fig. 7).

LOCALITY AND HORIZON. Sobova Valley, locality B.650, in the highest beds of the Seydişehir Shales, about 33 metres from the top of the Sobova Formation.

DESCRIPTION. The cranidium has an elongated, semielliptical glabella that occupies two-thirds the length and half the basal breadth of the cranidium and is bounded by broad, shallow axial furrows. The glabella carries a small tubercle slightly in front of centre and in-line with a pair of slight indentations in the sides of the glabella. One specimen (Pl. 1, fig. 1) shows these indentations linked to the median tubercle by shallow furrows which form a chevron, apex directed forwards, but it is not clear whether they are primary structures because similar furrows, almost certainly the result of crushing, diverge forwards from the median tubercle. The hindmost portion of the cranidium is imperfectly preserved but there are traces of a pair of subtriangular occipital lobes comparable with those found in other species of *Geragnostus*. Though incomplete, an otherwise broad border becomes slightly narrower posterolaterally and is delimited by a broad border furrow.

The pygidium is strongly arched both longitudinally and transversely, has a maximum breadth slightly greater than the median length and is semiellipitical in plan. The anterior margin (excluding the articulating half-ring, which is missing) is transversely straight medially but then runs backwards slightly to the articulating facets ; these are bounded by furrows that coalesce with the lateral border furrow, which in turn delimits a narrow border. As far as can be seen, there are no posterolateral border spines, but this part of the exoskeleton is imperfectly preserved. The

frontal breadth of the axis is equal to half, its median length about five-sixths, that of the pygidium. The frontal two-fifths of the axis is composed of two unequal axial rings, the anterior of which is slightly the smaller. The median quarter or so of this part of the axis is occupied by a longitudinal structure, formed by the fusion of the median lobes of the axial rings, and the posterior half was probably produced dorsally to form a blunt spine, judging by the broken surface remaining. The ring furrows curve forwards gently at inner and outer ends, and both they and the axial furrows are deep and broad. The remainder of the axis is poorly defined and the axial furrows are scarcely discernible, though they can be seen to curve gently to the semielliptical tip, just in front of which is a small median tubercle (see Pl. 1, fig. 8). The posterior portion of the axis carries traces of a number of small pits like those on the pygidium of *Glyptagnostus* as described and figured by Öpik (1961, text-figs 15, 16) who termed them muscle spots. Apparently similar structures behind the pygidial axis of *Galbagnostus* have been described as muscle pits by Whittington (1965 : 308).

Discussion. The cephalon of the new species has no obviously distinctive features to separate it from approximately contemporaneous members of *Geragnostus*, such as *G. occitanus* Howell (1935 : 231 ; see also Dean 1966 : 274) from the lower Arenig Series of southern France. The latter species has a distinctive pygidial axis in which the anterior, segmented portion is relatively much larger than that of *G. lycaonicus*. The axial furrows of the pygidium of *G. occitanus* display considerable variation and may become completely effaced. There is insufficient material of the new species to test for such variation, but similar effacement of the axial furrows affects only the posterior half of the pygidial axis of *G. lycaonicus*. In this respect it resembles *G. tullbergi* (Novák), from the Llanvirn Series of Bohemia (see Dean 1966 : 273) but the latter species may be readily distinguished by its narrower, slightly shorter axis with a proportionately smaller segmented portion of the axis. *G. tullbergi* was made the type species of *Geragnostella* Kobayashi 1939, to which *G. lycaonicus* would at one time have been assigned, but this genus has since been placed in the synonymy of *Geragnostus*.

The pygidium of *G. lycaonicus* shares some features—the form of the axial rings, the small median tubercle, and the undefined posterior portion of the axis—with that of *G. ? explanatus* Tjernvik (1956 : 193, pl. 1, figs. 13, 14), from the Lower Arenig of Sweden, but the Swedish species is distinguished by its wider border.

Family **RAPHIOPHORIDAE** Angelin, 1854

Genus ***AMPYX*** Dalman, 1827

Type species. *Ampyx nasutus* Dalman, 1827.

Ampyx ? sp.

Pl. 1, fig. 5

Figured specimen. BM. It.8658.

Locality and horizon. Locality C.543, 4·5 kms south of Kızılca, and in the upper half of the Seydişehir Shales.

Description. A small, poorly-preserved cranidium approximately 5 mm wide is the only representative of the Raphiophoridae yet known from the Seydişehir Shales. The fixigenae are convex, almost quadrant-shaped in plan, and the narrow (*exsag.*) posterior border, separated from the fixigenae by a deep, broad (*exsag.*) posterior border furrow, curves gently forwards abaxially. There is a faint suggestion of wrinkle-like ornamentation on the test of the left fixigena. The glabella is broken but the remains of the external mould suggest that it was relatively short and extended only a little way in front of the fixigenae.

Although detailed comparison of such inadequate material is not possible, perhaps the closest raphiophorid is *Ampyx ? villebruni* Thoral (1935 : 307) from the Arenig Series of St. Chinian, southern France. In an earlier paper (Dean, 1966 : 281) it was suggested that the affinities of Thoral's species lie with *Ampyxina*, and the same may be true of the Turkish specimen.

Family **CALYMENIDAE** Edwards, 1843

Subfamily **COLPOCORYPHINAE** Hupé, 1955

Genus ***COLPOCORYPHE*** Novák *in* Perner, 1918

Type species. *Calymene arago* Rouault, 1849.

Colpocoryphe sp.

Pl. 1, figs. 2, 9, 10

Figured specimens. BM. It.7994 (Pl. 1, figs. 2, 5), It.7995 (Pl. 1, figs. 9, 10).

Locality and horizon. Sobova Valley, locality B.650, in the highest strata of the Seydisehir Shales, and about 33 metres below the summit of the Seydişehir Formation.

Description. Two incomplete cranidia were found, both of which exhibit the bifid, ventrally-directed prolongations of the anterior border which have been interpreted as vincular structures (Dean, 1966 : 308 ; 1966a : 135). The more completely-preserved glabella has straight sides which converge forwards at about 30 degrees ; the anterior margin of the frontal glabellar lobe is slightly concave forwards, whilst the posterior margin of the glabella is transversely straight. There are three pairs of glabellar lobes ; the 1p and 2p pairs are almost equisized in Pl. 1, fig. 2, but those of Pl. 1, fig. 10 are markedly unequal and perhaps less distorted. The 3p lobes and frontal glabellar lobe are of approximately equal length and about two-thirds the size of the 1p and 2p lobes. Small, incomplete palpebral lobes are positioned opposite the 2p furrows and the anterior part of the 1p lobes.

Only one other species of *Colpocoryphe* of Arenig age is known, *C. thorali* Dean (1966 : 304) from the Extensus Zone of southern France. The latter differs from

the Turkish form in having a bell-shaped glabellar outline that is slightly constricted in front of the 2p glabellar lobes, a conspicuously longer frontal glabellar lobe, and less well-defined 2p and 3p glabellar furrows.

Subfamily **SYMHOMALONOTINAE** Kobayashi 1960

Genus ***NESEURETUS*** Hicks, 1872

TYPE SPECIES. *Neseuretus ramseyensis* Hicks, 1872.

Neseuretus sexangulus sp. nov.

Pl. 1, figs. 6, 11, 12

DIAGNOSIS. *Neseuretus* with hexagonal glabellar outline, the sides parallel as far as 2p glabellar furrows but then converging forwards strongly to transversely straight frontal glabellar lobe. 1p and 2p glabellar furrows well developed ; traces only of 3p furrows. Swollen anterior border about one-fifth length of cranidium. Eyes set well forwards, opposite 3p glabellar lobes. Posterior portions of fixigenae relatively large.

HOLOTYPE. BM. It.7996.

LOCALITIES AND HORIZONS. The holotype is from locality C.216, about 8 kms north-west of Seydişehir. A fragmentary cranidium at locality C.312, 6 kms west of Seydişehir, may represent the same species but is too poorly preserved for certain identification. Both localities are in the upper half of the Seydişehir Shales.

DESCRIPTION. The distinctive cranidium is preserved as an internal mould. Although the fixigenae are slightly distorted, it is calculated that the median length of the specimen is approximately three-fifths of the maximum breadth, measured across the genal angles. The glabella, excluding occipital ring, is roughly hexagonal in outline, almost as long as wide, with subparallel sides extending forwards as far as the 2p glabellar furrows. In lateral view the glabella is of low convexity, and when viewed anteriorly the dorsal surface appears slightly flattened (see Pl. 1, fig. 11). The median third of the posterior margin of the glabella is transversely straight, set slightly in front of the outer thirds which form gentle curves, concave forwards, around the bases of the 1p glabellar lobes. The anterolateral margins are almost straight and converge forwards at about 75 degrees so that the anterior margin, which has a slight median indentation, is equal to half the glabellar breadth. The main portion of the glabella, behind the convergent anterolateral margins, is divided into two pairs of glabellar lobes by deep glabellar furrows. The 1p lobes are slightly the largest and occupy one-third of the total glabellar length; they have the "cat's ear" outline found commonly in calymenaceids and are delimited anteriorly by deep, conspicuous 1p glabellar furrows that run inwards and back, expanding slightly at their inner ends but terminating so as to leave an unfurrowed median band one-third the breadth of the glabella. The 2p lobes are parallel-sided, bounded anteriorly by straight 2p glabellar furrows which diverge forwards at about 130 degrees. The 2p

furrows end adaxially in-line with the 1p furrows, whilst abaxially they become markedly shallow immediately before intersecting the axial furrows. The glabella in front of the 2p furrows forms an almost continuous structure, with only a pair of faint indentations to suggest the position of 3p glabellar furrows. The axial furrows are subparallel, deep and narrow as far forwards as the 2p glabellar furrows, where they become slightly broader and shallower. The median third of the occipital ring is parallel-sided, and the corresponding portion of the occipital furrow is shallow, but abaxially the furrow becomes conspicuously deeper and curves forwards around the bases of the 1p glabellar lobes. At the same time the occipital ring narrows markedly and ends in a poorly-defined pair of occipital lobes, the tips of which extend forwards adjacent to the basal part of the 1p lobes. The anterior border, although slightly damaged, is evidently characteristic for the genus, swollen medially, separated from the glabella by a broad, shallow furrow and from the fixigenae by still broader furrows. The eye lobes are small, sited well forwards opposite the 3p lobes and at a distance outside the axial furrows equal to one-third the breadth of the glabella. The proportion of the fixigenae behind the eyes is thus relatively large for the genus. The remainder of the exoskeleton is unknown.

Discussion. Whittard (1960 : 138 *et seq.*) has described the type and other species of *Neseuretus* from the Shelve Inlier of Shropshire and various parts of Wales. All, save one atypical species which should probably be excluded from the genus, are of Arenig age. In each case the combined anterior border and preglabellar furrow are appreciably longer than those of the Turkish species, and the latter differs also in the marked convergence of the axial furrows in front of the 2p glabellar furrows. *Neseuretus arenosus* Dean (1966 : 313) from the lower Arenig Series of southern France has generally similar glabellar proportions but is distinguished by the less angular outline of the front of the glabella, the smaller fixigenae, and the apparently less convex anterior border. The type species of *Neseuretus*, *N. ramseyensis* Hicks from the Lower Arenig of Wales (see Bates, 1969 : 22) has a more rounded glabellar outline and less distinct glabellar furrows than the Turkish species. *N. parvifrons* (M'Coy), also of Arenig age in Wales (Bates, 1969 : 26 ; Whittington, 1966 : 500), is distinguished by having a larger anterior border, and a glabellar outline that is more evenly convergent forwards. In both these species the posterior halves of the fixigenae are conspicuously smaller than those of *N. sexangulus*.

Neseuretus ? sp.

Pl. 2, fig. 9

A single fragmentary pygidium, preserved as an internal mould, has the anterior margin strongly convex forwards, whilst the posterolateral margins are straight, and diverge forwards at about 130 degrees. The left and sole surviving side-lobe is smooth for the most part but has two pleural ribs and a trace of a third rib in addition to the articulating facet and anterior half-rib. The ribs are delimited by shallow pleural furrows which cross only two-thirds of the side-lobe so as to leave a broad, smooth border. The axis extends to within a short distance of the pygidial tip and is infundibular in plan, with a marked break in outline behind the third axial ring.

There are five well-defined axial rings and a sixth less well defined, followed by a small terminal piece with semielliptical tip. The ring furrows are transversely straight and, apart from the first two, do not quite attain the broad, shallow axial furrows.

A similar axial outline has been described by Whittard (1960 : 142, 146) for *Neseuretus grandior* and *N. brevisulcus*, both from the Extensus Zone of the Arenig Series in the Shelve Inlier. In each case, however, the pygidial axis is parallel-sided behind the seventh axial ring, compared with the third ring in the Turkish form. The relative smoothness of the side-lobes, though it does not exclude the specimen from *Neseuretus*, is perhaps more suggestive of *Colpocoryphe*, but lack of the characteristic vincular furrows argues against such an identification. For the present I prefer to assign the pygidium questionably to *Neseuretus*.

FIGURED SPECIMEN. BM. It.8001.

LOCALITY AND HORIZON. Sobova Valley, locality B.650, in the highest portion of the Seydişehir Shales.

? Family **CHEIRURIDAE** Salter 1864

Cheirurid ? gen. et sp. indet.

Pl. 2, figs. 2, 5

FIGURED SPECIMEN. BM. It.8000.

LOCALITY AND HORIZON. Loc. C.160, about 5·5 kms west of Seydişehir, in the upper half of the Seydişehir Shales.

DESCRIPTION. A single, incomplete, poorly-preserved glabella of unusual type, with a fragment of the anterior border, is the only available, if doubtful, evidence for cheirurid trilobites in the Seydişehir Shales. The glabella is of inflated form, elliptical in plan, with breadth just over four-fifths of the maximum length. In lateral view the glabellar outline is tumid, strongly arched-down frontally, and there is evidence of at least two pairs, with a suggestion of a third pair, of glabellar furrows, preserved as narrow, lightly-impressed lines on the internal mould. Glabellar furrows interpreted as the 1p pair arch adaxially backwards towards, though they do not reach, the occipital furrow, whilst the 2p furrows are more transverse, only gently curved. The pairs of glabellar lobes so delimited are of large size, each about three-tenths of the length of the glabella. The axial furrows were evidently broad and deep, overhung on their adaxial sides by the tumid glabella. Traces of the anterior border show it was small and narrow, separated from the glabella by a furrow comparable in depth and breadth with the axial furrows. Only a fragment of the anterior branch of the facial suture remains, and meets the anterior margin of the cranidium at an obtuse angle.

It is difficult to assign such fragmentary material to a family with any degree of certainty, but the swollen glabella, the course taken by the glabellar furrows and the form of the outer portion of the anterior border suggest the Cheiruridae. Cranidia of this type are unusual in the Arenig Series but some comparison may be made with

forms such as *Pseudosphaerexochus* (*Pateraspis*) *inflatus* Poulsen (1965 : 104, pl. 9, esp. figs. 1–4), from the Skelbro Limestone of Bornholm. This unusually early representative of the genus differs from the Turkish specimen in having a glabella that is less tumid in cross-section, a slightly larger anterior border, and more deeply-incised glabellar furrows. However, it shares enough features, such as the swollen glabella, conspicuously arched in lateral view and elliptical in plan, the position and direction of the glabellar furrows, and the shape of the anterior border, to suggest a possible affinity.

Family **NILEIDAE** Angelin, 1854

Genus ***SYMPHYSURUS*** Goldfuss, 1843

TYPE SPECIES. *Asaphus palpebrosus* Dalman, 1827.

Symphysurus blumenthali sp. nov.

Pl. 2, figs. 1, 3, 4, 6–8, 10 ; Pl. 3, figs. 5, 6, 10

DIAGNOSIS. *Symphysurus* with large, strongly convex glabella about four-fifths as broad as long, expanding slightly at front. Median tubercle developed. Large palpebral lobes situated just behind centre, each equal to two-fifths of glabellar length. Pygidium about twice as broad as long, with posterior margin strongly curved. Straight-sided axis clearly visible only on internal mould.

HOLOTYPE. BM. It.7997 (Pl. 2, figs. 1, 7, 10).

PARATYPES. BM. It.7998 (Pl. 2, fig. 3) ; It.7999 (Pl 2, figs. 4, 6, 8).

LOCALITY AND HORIZON. All the type material is from locality B.650 in the Sobova Valley. The specimens were collected from a thin band of weathered sandy limestone about 33 metres below the summit of the Seydişehir Formation.

DESCRIPTION. The exoskeleton is known only from disarticulated cranidia and pygidia. The cranidium is strongly convex both longitudinally and transversely, with projected length about two-thirds of the breadth. The glabella is large, occupies just over half the maximum basal breadth of the cranidium, and its sides are subparallel as far as the front of the palpebral lobes, beyond which the breadth expands by about one-quarter. Owing to its marked convexity, the front of the glabella appears rounded in plan, but when viewed anteriorly the margin of the frontal glabellar lobe is seen to be only slightly convex sagittally (see Pl. 2, fig. 7). The shallow axial furrows diverge forwards gently from the back of the cranidium until just in front of the posterior border furrow, where they become subparallel as far as the front of the palpebral lobes ; they then deepen and flex gently around the frontal glabellar lobe. Deep, slot-like anterior pits are sited in the axial furrows just in front of the palpebral lobes. There is no anterior border. A conspicuous tubercle is situated well behind the centre of the glabella. The occipital ring is not differentiated anteriorly from the glabella but its posterior margin projects backwards in a broad curve, with a small notch, marking the position of the axial furrows,

situated at either end, beyond which the straight posterior margins of the posterior border run slightly back abaxially. The eyes and librigenae have not been found, but large, elongated, semielliptical palpebral lobes, which lack palpebral furrows, are sited immediately outside the axial furrows. When the cranidium is viewed laterally in its presumed life attitude, the flat upper surface of the palpebral lobes is declined forwards at about 40 degrees. When the cranidium is viewed with the palpebral lobes horizontal, the latter appear equal to two-fifths of the glabellar length, with one-fifth of the latter behind them. The anterior branches of the facial suture run parallel to, and immediately outside, the anterolateral margins of the frontal glabellar lobe and then turn adaxially through slightly more than a right-angle so as to meet frontally in an unbroken gentle curve. The posterior branches run outwards and slightly backwards from the rear of the eyes in almost straight lines, so that the posterior portions of the fixigenae are small and triangular.

The hypostoma and thorax are not known.

The pygidium is about twice as broad as long. The anterior margin arches forwards gently while the posterior margin forms a stronger, parabolic curve, so that the two curves meet at almost a right-angle. In both side and posterior views the pygidium appears moderately convex, with the top of the axis almost continuous with that of the side-lobes. The front of the axis has a breadth equal to one-third of the maximum breadth of the pygidium. The axial furrows are straight, converging backwards gently, and both they and the ring furrows are almost obsolete on the external surface of the test. On the internal mould the axial furrows appear deeper and at least three axial rings are visible, together with a small articulating half-ring, but it was not possible to examine the tip of the axis. The side-lobes have a pair of large articulating facets, just behind each of which is a broad (*exsag.*), shallow pleural furrow, visible only on the internal mould.

The surface of the glabella is ornamented with numerous thin, anastomosing ridges which form a Bertillon pattern and are subparallel to the margins of the frontal glabellar lobe. The surface of the pygidium is smooth.

A pygidium (Pl. 3, fig. 6) from the type locality has the axis better-defined than that of *S. blumenthali*, but is slightly crushed ; its specific position is in doubt, and it is termed merely *Symphysurus* sp. Likewise a fragmentary specimen (Pl. 3, figs. 5, 10) that shows the doublure ornamented by subparallel terrace-lines, but is too incomplete for determination. Another pygidium of *Symphysurus* (Pl. 4, fig. 2) from the Seydişehir Shales at locality C.312 has the appropriate outline and proportions for *S. blumenthali*. but the axis appears to be better-segmented and there are traces of more pleural ribs.

Discussion. A modern diagnosis and modified illustration of the type species of *Symphysurus*, *Asaphus palpebrosus* Dalman 1827, have been published more recently by Poulsen (*in* Moore 1959 : O 358, Fig. 267, 8). They show that the Swedish species differs from *S. blumenthali* in having a relatively shorter glabella with axial furrows that are more divergent forwards, and eyes set farther forwards, so that the posterior portions of the fixigenae are proportionately larger. The pygidium of *S. palpebrosus* has a more rounded outline and an axis that is better defined and perhaps shorter, though this feature is hard to assess.

The pygidium of *S. blumenthali* appears to be very close to that of *S. angustatus* (Sars & Boeck) from the late Tremadoc and early Arenig Series of Norway and Sweden (Tjernvik 1956 : 211, pl. 2, figs. 24, 25). As far as can be judged from illustrations, both have an axis that is well defined on the internal mould but obsolete on the outer surface of the test. The cephalon of *S. angustatus* is less tumid and has a more straight-sided glabella that is relatively narrower. The slight carination of the glabella of *S. angustatus* is of dubious significance. The trilobite from the early Ordovician of the Montagne Noire, south-western France, described originally by Bergeron (1895 : 478, pl. 5, figs. 6–8) as *Aeglina sicardi* is clearly a *Symphysurus* and is sometimes cited as a variety of *S. angustatus*. The glabella is slightly shorter than that of *S. blumenthali*, the median tubercle and palpebral lobes are sited farther back, and the front of the glabella is more convex in plan. The pygidium attributed by Bergeron to the species is much longer than any of those considered above, with a wide, concave border and long, narrow axis ; probably it does not belong to the genus.

Family **ASAPHIDAE** Burmeister, 1843

Trilobites of generalized asaphid type are represented by locally abundant fragments in the resistant, thin bands of sandy limestone in the Seydişehir Shales. Such remains invariably pose problems of identification, particularly when the hypostoma is lacking. Consequently it has rarely proved possible to give more than a tentative generic assignment to the material.

Genus ***PARAMEGALASPIS*** Thoral *in* Jaanusson, 1956

Type species. *Megalaspis* (*Paramegalaspis*) *immarginata* Thoral, 1935.

Paramegalaspis sp.

Pl. 5, figs. 5, 8. 9, 11

Figured specimens. BM. It.8016 (Pl. 5, fig. 8) ; It.8019 (Pl. 5, fig. 11) ; It.8020 (Pl. 5, fig. 5) ; It.8021 (Pl. 5, fig. 9).

Localities and horizons. It.8021 is from locality C.314, in the upper half of the Seydişehir Shales, about 8 kms north-west of Seydişehir. The other three specimens are from locality B.650, in the highest beds of the Seydişehir Shales in the Sobova Valley, south of Beyşehir.

Description. A single incomplete cranidium (Pl. 5, fig. 9) has the median length rather more than three-quarters of the basal breadth. The glabella is poorly defined but as far as can be seen the breadth is about five-eighths of the median length. The front of the glabella is almost semicircular and the sides are parallel except behind the palpebral lobes, where they are slightly digergent posteriorly. The anterior portion of the cranidium—frontal area of Harrington, Moore & Stubblefield *in* Moore 1959 : O 120—shows no distinct differentiation into preglabellar field and anterior border, but the marginal area corresponding to the anterior border is slightly flattened,

separated from the glabella by a broad (*sag.*), gently depressed area which corresponds to the preglabellar field. The occipital ring is almost indiscernible, although faint traces occur near the axial furrow, and there is a small median tubercle on the glabella in a position estimated to be immediately in front of the obsolete occipital furrow. There are traces of a narrow (*sag.*) doublure along the posterior margin of the occipital ring, and an apodeme is visible at the end of the right axial furrow. The eyes are positioned opposite the centre, and have a length (*exsag.*) equal to one-quarter, of the combined glabella and occipital ring. The flattened palpebral lobes are sub-semicircular in plan with no palpebral furrows, although the internal mould suggests a marginal thickening of the test. The anterior branches of the facial suture arch forwards and out from the eyes until half-way to the margin, at which point they are in-line abaxially with the centres of the palpebral lobes ; they then curve forwards and strongly inwards to meet at a blunted obtuse angle. The posterior branches run outwards and slightly back from the eyes in a very gentle curve, concave forwards, for a distance equal to nearly half the breadth of the glabella, and then turn backwards sharply to cut the posterior margin at almost a right-angle. The posterior area of each fixigena so formed is small, sub-triangular in plan, and carries a slightly curved posterior border furrow which runs parallel to the posterior margin and widens (*exsag.*) a little abaxially.

An almost complete left librigena (Pl. 5, fig. 8) from the same locality as the above cranidium shows the facial suture following a generally similar course, though the anterior branch appears straighter in front of the eye, perhaps due to crushing. The anterolateral margin is straight for the most part but becomes curved both frontally and, more strongly, near the genal angle, which is produced to form a moderately-long, slim spine, directed backwards and slightly outwards. A hypostoma preserved as an internal mould (Pl. 5, fig. 11) shows the characteristics of the genus and may be compared with one illustrated as *Paramegalaspis* sp. from the Lower Arenig Series of the Montagne Noire, southern France (Dean 1966 : 326, pl. 18, fig. 9). A pygidium (Pl. 5, fig. 5) preserved as an internal mould and exhibiting a uniformly narrow doublure has generally similar proportions to material illustrated from the Arenig Series of the Montagne Noire, for example *Paramegalaspis* cf. *frequens* Thoral (Dean 1966, pl. 18, figs. 2, 10, 13). The pleural ribs of the Turkish specimen appear to be slightly less well defined but further comparison is difficult with so little material.

Discussion. According to the Treatise on Invertebrate Paleontology (Jaanusson *in* Moore 1959 : O 349) *Paramegalaspis* has no border on either cephalon or pygidium ; the frontal area is 0·2 to 0·25 of the cephalic length ; librigenal spines are present ; and the pygidium has a flattened axis and a narrow doublure. Material from the type area in southern France has been shown to exhibit a small amount of cephalic variation so that the anterior border may be moderately well defined (Dean 1966 : 326) or almost obsolete, as is the case for the Turkish cranidium now figured. Jaanusson (*loc. cit.*) claimed *Dolerasaphus*, type species *D. laevis* Harrington & Leanza (1957 : 157), as a synonym of *Paramegalaspis*, but the illustrations of *D. laevis* show that it, like the Turkish cranidium now described, has a frontal area which occupies slightly less than the 0·2 to 0·25 of the cephalic length stipulated in the Treatise. Such small differences are probably not valid at generic level, particularly

when one is dealing with compressed specimens, and *Dolerasaphus* shows no other significant differences from *Paramegalaspis* as generally interpreted, though the hypostoma has not yet been described.

Genus ***MEGISTASPIS*** Jaanusson 1956

TYPE SPECIES. *Trilobites limbatus* Boeck, 1838.

Megistaspis sp.

Pl. 3, fig. 8 ? ; Pl. 4, fig, 5 ; Pl. 5 figs. 1 ?, 3, 4, 6, 10

FIGURED SPECIMENS. BM. It.8007 (Pl. 3, fig. 8); It.8013 (Pl. 4, fig. 5) ; It.8014 (Pl. 5, fig. 1) ; It.8015 (Pl. 5, figs. 3, 4, 6) ; It. 8017 (Pl. 5, fig. 10).

LOCALITIES AND HORIZONS. In the area north-west of Seydişehir the genus was collected at localities C.310, 312 and, most commonly, C.314, all of them in the upper half of the Seydişehir Shales. It was found less commonly in the highest part of the shales at B.650, in the Sobova Valley. Fragments referred questionably to the genus were obtained at localities C.319 and C.320 in the Upper Greywackes.

DESCRIPTION. Several fragmentary pygidia have been collected which correspond to the generic diagnosis given by Jaanusson (*in* Moore 1959 : O 347). The largest pygidium (Pl. 5, fig. 10) is parabolic in plan, gently convex both longitudinally and transversely, with median length about five-sixths of the maximum breadth as measured across the anterolateral angles. The front of the axis of this specimen is more than one-third of the maximum breadth of the pygidium, and the sides are straight, converging backwards at approximately 25 degrees to the indistinct tip. The whole axis, excluding the small articulating half-ring, occupies four-fifths of the pygidial length. The axial furrows are broad, shallow and for the most part poorly defined on the outer surface, so that the distinction between axis and side-lobes is not clear except frontally. The side-lobes are of low convexity, with large facets cutting obliquely across the abaxial halves of the anterior half-ribs. There is almost no trace of other furrows and the pygidium is bounded by a broad (*tr.*) border which becomes still broader (*sag.*) between the axis and the tip of the pygidium.

The above remarks apply only to the largest pygidium, and one of the best-preserved smaller specimens (Pl. 5, figs. 3, 4, 6) shows slight differences. For example the length is about nine-tenths of the maximum breadth, though such proportions have been affected to a certain degree by compression, particularly in the large specimen noted above. Certainly the axis and side-lobes of the smaller pygidium show more evidence of segmentation, and some of the pleural ribs have traces of interpleural furrows (see also specimen It.8014, Pl. 5, fig. 1). The doublure appears to correspond in size to the smooth border. This pygidium (It.8015) is preserved as an internal mould and a partly-exfoliated smaller specimen (Pl. 4, fig. 5) is of particular interest as it demonstrates the lack of furrows on the outer surface of the test, while the internal mould shows evidence of ten axial rings and at least seven pairs of pleural ribs.

No corresponding cranidium has yet been found, but an incomplete right librigena (Pl. 3, fig. 8) is questionably referred to *Megistaspis*?. The genal angle is produced to form a short, sharp spine and part of the test is missing so as to reveal the narrow doublure. A fragment of another right librigena (Pl. 5, figs. 2, 7) represents one of the largest trilobite remains found in the Seydişehir Shales. It is unusually deep anteriorly and the ventral side shows conspicuous ridge-like structures running at right angles to the margin. The incomplete anterior branch of the facial suture suggests *Megistaspis* rather than any of the other asaphid genera found in the area, but the material is insufficient for certain identification.

Megistaspis (*Megistaspidella*) of Jaanusson (1956 : 71 ; *in* Moore 1959 : 348, Fig. 259, 3) has a broadly similar pygidium but the tip is slightly more pointed and the side-lobes and axis are smooth, except for two axial rings. The type species, *Entomostracites extenuatus* Wahlenberg 1821, was figured also by Schmidt (1906, pl. 7, figs. 1, 2a, 3a) whose illustrations of the pygidium show it to be very like the Turkish specimens, though the border is more concave and wider near the bluntly pointed tip.

Genus ***PTYCHOPYGE*** Angelin, 1854

TYPE SPECIES. *Asaphus angustifrons* Dalman, 1827.

Ptychopyge sp.

Pl. 4, figs. 7, 8 ?

In 1964 Balashova erected a new subfamily Ptychopyginae and included therein the type genus and three new genera, *Metaptychopyge*, *Paraptychopyge* and *Pseudoptychopyge*. The present scanty material from the Seydişehir Shales does not lend itself to such detailed treatment and the specimens are referred merely to *Ptychopyge* sensu lato.

An isolated hypostoma (Pl. 4, fig. 7) from locality C.310 lacks the anterior wings but the maximum breadth, measured across centre, is three-quarters of the median length. The median body is moderately convex, occupies slightly more than three-quarters of the median length of the hypostoma, and is an elongated ellipse in plan, two-thirds as broad as long. It is divided into two unequal lobes by a median furrow which becomes almost effaced medially, runs in a gentle curve, convex forwards, and forms deep notches at either end. The crescentic posterior lobe so formed occupies about one quarter of the length (*sag.*) of the median body. The front of the hypostoma is incompletely preserved, but the lateral border starts opposite the middle of the anterior half of the median body, and the lateral margins are gently convex abaxially. The lateral border is continuous with the posterior border, but the latter is broader (*exsag.*), slightly flattened, and has a short, narrow median notch. The border is separated from the median body by a broad, shallow border furrow. The overall appearance is similar to that of the hypostoma of *Ptychopyge angustifrons* (Dalman) (see Jaanusson *in* Moore 1959 : O 339, Fig. 250, 2c) but differs in having a narrower lateral border, whilst the posterior lobe of the

median body is slightly longer and better differentiated. One may also compare the hypostoma of *Ptychopyge lesnikovae* Balashova (1964, pl. 1, fig. 6) but the latter has a slightly larger, more pointed median notch and the posterior lobe of the median body is almost continuous with both the anterior lobe and the posterior border.

The pygidium from locality C.312*a* questionably assigned to *Ptychopyge* (Pl. 4, fig. 8) is subparabolic in plan, has a low convexity and a maximum breadth rather more than one and a half times the median length. The axis has a frontal breadth equal to two-sevenths that the pygidium and extends back for more than four-fifths of the pygidial length; in plan it has a slightly infundibular appearance owing to the converging of the sides at about 30 degrees for half the length, followed by their running parallel to the rounded tip. There are four rings on the anterior half, followed by two faint additional rings, and the rest of the axis is smooth. Outside the broad, shallow axial furrows are flattened side-lobes which merge imperceptibly with a smooth, concave border that widens posteriorly. The inner portion of the side-lobes is lightly furrowed with five pairs of ribs in addition to the anterior half-rib ; each rib, in turn, carries a faint interpleural furrow which divides it into anterior and posterior half-ribs, the latter slightly the larger. The furrowing of the pleural ribs is a feature not usually found in *Ptychopyge*, though it can occur in related genera as shown by the internal mould of a pygidium of *Metaptychopyge truncata* Nieszkowski sp. (Balashova 1964, pl. 8, fig. 7), the external surface of which exhibits smooth ribs.

Asaphid gen. et sp. undetermined

Pl. 3, figs. 1, 2, 4, 7, 9, 11 ; Pl. 4, figs. 1, 3, 4, 6, 9

Figured specimens. BM. It.8002 (Pl. 3, figs. 1, 9, 11), It.8003 (Pl. 3, figs. 2, 4, 7), It.8008 (Pl. 4, figs. 1, 3, 4), It.8010 (Pl. 4, figs. 6, 9).

Localities and horizons. Localities C.310 and C.312*a*, both 6 kms west of Seydişehir and in the upper half of the Seydişehir Shales ; also locality B.650 in the Sobova Valley, where it forms part of the highest Seydişehir Shales.

Description. Certain asaphid fragments exhibit characters which exclude them from the other genera so far recorded from the Beyşehir region but are inadequate for generic assignment. No undistorted cranidium has been found, but a well-preserved left librigena (Pl. 3, figs. 1, 9, 11) gives useful information regarding the course of the facial suture and the position of the eye. The palpebral lobe is semi-circular in outline, positioned relatively far forwards so that the projected length of the cephalon in front of the eye is 0·34 of the estimated median length. The length of the eye is 0.28 that of the cephalon. From this and other specimens the facial suture is seen to be of isoteliform type, with the anterior branches meeting frontally at an obtuse angle. There is a weakly-developed, low anterior border, bounded by a shallow furrow which curves evenly backwards abaxially to meet the lateral margins immediately in front of the conspicuous, broadly-rounded genal angles. Pl. 4, figs. 6, 9 shows another left librigena of apparently the same type but with part of the test removed to reveal the doublure, which is narrow, dorsally concave, except at its inner margin where it becomes slightly reflexed, and ornamented with closely-spaced, subparallel terrace-lines.

No corresponding cranidium has been found well preserved. Pl. 3, fig. 4 shows the glabella and occipital ring to be continuous, bounded by broad, shallow, almost parallel axial furrows. The dorsally flattened palpebral lobes are slightly inclined abaxially, and are situated close to the sides of the glabella. Traces of a shallow furrow circumscribing the front of the glabella suggest the presence of an anterior border.

Only six segments of the thorax have been found preserved (Pl. 4, figs. 1, 3, 4) and are of asaphid type, with a broad, flattened axis occupying more than one-third of the breadth. The conjoined cephalon resembles the material already noted but the front is distorted by crushing.

Discussion. The material agrees in most respects with specimens attributed to *Paramegalaspis*, as well as the type species of its subjective synonym *Dolerasaphus*. The latter (Harrington & Leanza 1957 : 157) was stated to have no anterior border, but was founded on only a single specimen. As noted earlier, this feature has been described as slightly variable in *Paramegalaspis* and consequently the anterior border alone should not exclude the Turkish specimen from the genus. However, a conspicuous feature of the present material is its possession of broadly-rounded genal angles, a character found in such genera as *Asaphus*, in which the glabellar lobation is quite different, and *Asaphus* (*Neosaphus*), the type species of which has the eyes set much farther back (Jaanusson in Moore 1959 : O 336), though other species attributed to the latter subgenus may have the eyes set farther forwards and possess librigenal spines (see Jaanusson 1953). Rounded genal angles have not been reported from *Paramegalaspis* or similar forms, but crushing and the fragmentary nature of the material from the Seydişehir Formation preclude more detailed comparison, and in the circumstances I prefer not to make a definite generic assignment.

Family **TAIHUNGSHANIIDAE** Sun, 1931

Genus ***TAIHUNGSHANIA*** Sun, 1931

Type species. *T. shui* Sun, 1931.

Taihungshania sp.

Pl. 3, fig. 3

Figured specimen. BM. It.8004.

Locality and specimen. Locality C.543, 4·5 kms south of Kızılca and in the upper half of the Seydişehir Shales.

Description. The genus is represented in the Beyşehir region by a single incomplete pygidium which lacks both the posterior part of the axis and the posterior margin, but is estimated to have been approximately three-quarters as long as wide. The axis has straight sides, bounded by shallow axial furrows which converge backwards at about fifteen degrees. Only the anterior half of the axis is preserved, on which there are six axial rings of uniform width (*sag.*), separated by shallow, trans-

versely straight ring furrows. The right side-lobe only is preserved and has six well-defined ribs and traces of two further ribs. The anterior half-rib is transversely straight for about one-third of its length (*tr.*) as far as a well-defined fulcrum, but then turns back through about forty-five degrees and is bounded anterolaterally by a large facet. From front to rear of the pygidium the ribs become progressively more strongly directed backwards, each rib being parallel-sided for half its length (*tr.*) but then turning backwards and tapering before dying-out. The angle through which the ribs turn backwards becomes progressively less from front to rear of the pygidium, and those of the fifth pair are almost straight. The first three ribs extend across about three-quarters of the breadth of the side-lobe and then almost die out towards the pygidial margin. Although, according to Jaanusson (*in* Moore 1959 : 356), there is no pygidial border in *Taihungshania*, nevertheless the specimen shows what appears to be a true, almost smooth border which becomes broader towards the tip of the pygidium. The pygidium of the type species *T. shui* Sun (1931, pl. 2, figs. 1a, b) appears to be generally similar, though with more pleural ribs, and the supposed absence of a border may be more apparent than real owing to the state of preservation. The portion of the border in-line with the third rib is slightly swollen and the margin there is produced backwards to form a spine which is only partially preserved. Most of the surface of the test is smooth, but that of the axial rings and the posterior bands of the ribs is pitted. Similar pitting occurs also in the first two pleural furrows.

Discussion. In the Montagne Noire, southern France, *Taihungshania* [*Miquelina*] *miqueli* (Bergeron) has been used as an index fossil for part of the Extensus Zone of the Arenig and has been recorded from China by Sheng (1958 : 192). The pygidium of *T. miqueli* was refigured by Dean (1966, pl. 16, figs. 3, 4), and differs from that of the present specimen in having a narrower axis and a greater number of ribs, as well as a narrower border upon which the pleural furrows are slightly more impressed. *Taihungshania landayranensis* (Thoral), also from the Lower Arenig of the Montagne Noire (Dean, 1966 : 331–332, pl. 16, fig. 7), has a number of ribs broadly comparable with that of the Turkish specimen but relatively smaller side-lobes.

III. AGE AND RELATIONSHIPS OF THE TRILOBITES

A generalized section through the Seydişehir Formation is given below (Fig. 3) together with the estimated stratigraphic levels of the principal localities known at present in the Seydişhir–Sobova region (see Fig. 1). It must be emphasized that in strata of this type, which have undergone a considerable amount of folding, the horizons given can be no more than approximations.

The trilobites of the Seydişehir Formation, although relatively sparse, show unmistakable evidence of belonging, at least in part, to what has been termed variously the Calymenid—Trinucleid Province or the *Selenopeltis*—Fauna (Whittington 1966a). These names are sometimes difficult to apply owing to lack of the eponymous trilobite groups and I prefer to use the term Tethyan Province or Fauna (Dean 1967). Geographically the Tethyan faunal province has been shown to have extended westwards from the Mediterranean to encompass the Anglo-Welsh area, south-east Newfoundland and Florida, if not still farther. To the east it extended at least as far as south-west China during Arenig times and probably beyond, into Australia.

The trilobite families and genera characteristic of the Mediterranean part of the Tethyan region during the early Ordovician are Asaphidae (*Paramegalaspis, Plesiomegalaspis*), Colpocoryphidae (*Colopocoryphe*), Synhomalonotidae (*Neseuretus*) [these two families are sometimes regarded as subfamilies of the Calymenidae], Taihung-

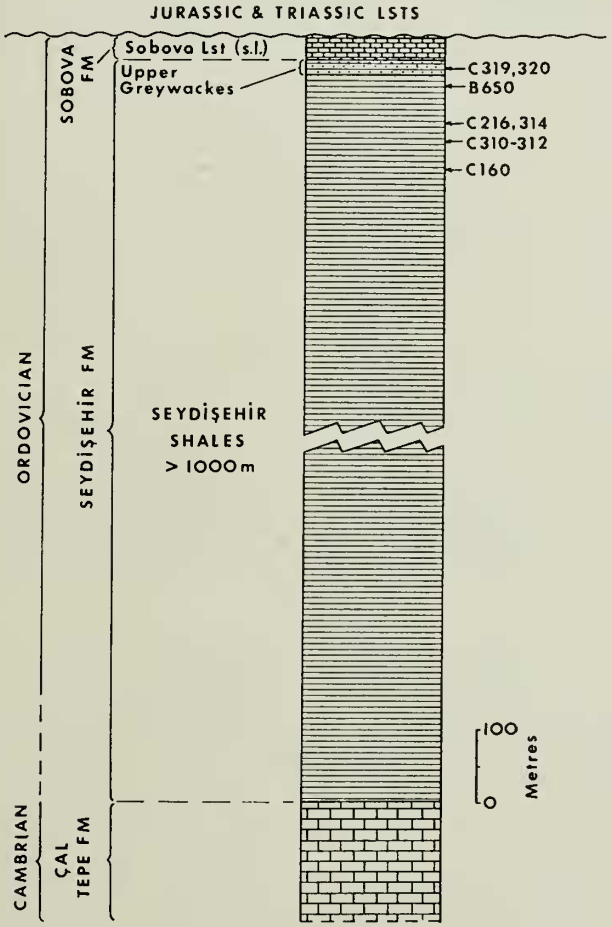

Fig. 3. Composite stratigraphical column for the Ordovician and adjacent rocks of the Beyşehir-Seydişehir district, showing the approximate horizons of fossil localities in the Seydişehir Shales and Upper Greywackes. C.309 and C.543 have been omitted owing to even greater uncertainty regarding their horizon, though it is undoubtedly in the upper half of the Seydişehir Shales.

shaniidae (*Taihungshania*) and Trinucleidae (*Myttonia, Hanchungolithus*). Of these the trinucleids, so useful in Ordovician stratigraphy, have unfortunately not yet been found in the higher Seydişehir Shales, but all the other families and most of the genera are represented, though never in large numbers. Other genera are present

which, as noted later, support Whittington's (1966a) contention that the boundaries between Ordovician faunal provinces are sometimes difficult to draw. The few graptolites found at C.206 and C.310 (see Fig. 2) indicate an Arenig age (Toghill *in* Dean & Monod, 1970) and supplement the evidence provided by the trilobites.

In a previous paper (Dean & Monod 1970) preliminary lists of trilobite identifications were given for the known fossiliferous localities in the Seydişehir Formation. The foregoing descriptions enable a series of revised faunal lists to be compiled, as follows:

Locality B.650.	Asaphid gen. et sp. undetermined, *Colpocoryphe* sp., *Geragnostus lycaonicus* sp. nov., *Megistaspis* ? sp., *Neseuretus* ? sp., *Paramegalaspis* sp., *Symphysurus blumenthali* sp. nov., *Symphysurus* sp.
Locality C.160.	Cheirurid ? gen. et sp. indet., *Paramegalaspis* ? sp.
Locality C.216.	*Neseuretus sexangulus* sp. nov., *Paramegalaspis* sp.
Locality C.309.	*Paramegalaspis* sp.
Locality C.310.	Asaphid gen, et sp. undetermined, *Megistaspis* ? sp., *Ptychopyge* sp.
Locality C.311.	*Paramegalaspis* sp.
Locality C.312.	*Megistaspis* sp., *Neseuretus* ? sp., *Paramegalaspis* sp., *Symphysurus* sp.
Locality C.312a.	Asaphid gen. et sp. undetermined, *Paramegalaspis* sp., *Ptychopyge* ? sp.
Locality C.314.	Asaphid gen. et sp. undetermined, *Megistaspis* sp., *Paramegalaspis* sp.
Localities C.319 & C.320.	Asaphid fragments, possibly *Megistaspis* sp.
Locality C.543.	*Ampyx* ? sp., *Taihungshania* sp.

Upper Cambrian and Tremadoc strata have not been found in this region, and the nature of the Cambrian—Ordovician boundary is not yet known. Certainly there are some hundreds of metres of clastic sediments lying between undoubted Middle Cambrian and Arenig strata, but so far there is no evidence for their age. The lower half, at least, of the Seydişehir Shales has not yet yielded identifiable fossils and the lowest fossiliferous horizon, at locality C.210, produced only unidentifiable fragments of uncertain affinities. Probably the oldest trilobites collected from the shales are from the upper part of the succession at C.160, where the Tethyan genus *Paramegalaspis* is accompanied by a cheirurid which, though unidentifiable, nevertheless represents a group that is more Baltic than Tethyan in aspect, a suggestion that receives some support from the few brachiopods at the same locality.

The small sample from C.543 is of particular interest as it includes the only specimen of *Taihungshania* yet known from the Seydişehir Shales. Although the latter is not identical with any of the species described from southern France or south-west China, it is accompanied here by a small raphiophorid apparently allied to *Ampyx ? villebruni*, described by Thoral from the Arenig Series of the Montagne Noire.

One of the youngest trilobite faunas, and also the most prolific, from the Seydişehir

Formation was collected at B.650 in the Sobova Valley, about 33 metres below the base of the overlying Sobova Limestone. *Colpocoryphe* and *Neseuretus* are typical Tethyan elements, and both genera had a long vertical range there, from Lower Arenig to Caradoc Series. *Colpocoryphe* is essentially a western Tethyan form, extending westwards to Florida and eastwards to Turkey but *Neseuretus* is more widespread in an easterly direction and is well known from the Lower Ordovician of south-west China. The *Geragnostus* present belongs to a group of species found particularly in the Arenig and Llanvirn of the Mediterranean region and Bohemia. At least three asaphid genera are present, and although *Paramegalaspis* is again of Tethyan type, *Megistaspis* and *Symphysurus* are northern European forms. The presence of *Symphysurus* at this point in the succession foreshadows the even greater abundance of the genus, together with additional Baltic elements, in the Sobova Limestone, and suggests at least a temporary break in the relatively uniform Tethyan Lower Arenig faunas, accompanied by the establishment of new faunal links with the Baltic region and Scandinavia.

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